STRATEGY RESEARCH PROJECT

COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENTS (CRADA): ARE THEY VALUE ADDED?

BY

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USAWC STRATEGY RESEARCH PAPER

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ABSTRACT

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Congress increasingly views technology transfer between federal laboratories and industry as a major factor contributing to the economic strength of the United States. In 1986, Congress sought to enhance this transfer by authorizing "Cooperative Research and Development Agreements (CRADA)." This paper reviews the history of CRADA and some different projects funded through this process to determine if it adds value to America. Is the CRADA process just a social welfare program for the federal laboratories and the industrial base?

Contents

The United States should develop a National Strategic Technology Policy with a specific statement of the ends, ways, and means. The National Security Strategy [1] offers general guidance:

> Our economic strategy views the private sector as the engine of economic growth. It sees government's role as a partner in the private sector--acting as an advocate of U.S. business interests; leveling the playing field in international markets; helping to boost American exports; and finding ways to remove domestic and foreign barriers to creativity, initiative, and productivity of American business.

Presently, our unfocused technology policy resides in at least twelve federal laws, sixteen federal cooperative research and development agreement (CRADA) sponsors, hundreds of regulations, and no consistent guidance among agencies for the establishment of CRADAs. Furthermore, nine congressional committees oversee different parts of the federal research and development (R&D) budget.[2] This hodgepodge clearly does not incorporate strategic vision, nor does it establish the ends, ways, and means of achieving strategic goals. We have a piecemeal system! The cooperative research and development agreement (CRADA) is one of these pieces. The following analysis addresses CRADA effectiveness in adding value to America.

The WHY

That new technology enhances economic growth is well-established in theoretical and empirical research in economics. Several distinguished economists have conducted research in this area, among them Nobel Laureate Robert M. Solow, Massachusetts Institute of Technology;

Moses Abramovitz, Stanford University; Richard Nelson, Columbia University; Edwin Mansfield, University of Pennsylvania; and Fredric M. Scherer and Zvi Griliches, Harvard University. All of them conclude that more than half the historical growth in per capita income in the U.S. is attributable to advances in technology; they demonstrate that the total economic return on investment in R&D is more than twenty times as high as that for other forms of investment.[3] Beginning in 1980, Congress passed a series of laws requiring federal agencies to set up programs promoting government-industrial partnerships. By offering U.S. companies two valuable resources-- the knowledge and the equipment of government scientists--Congress and the President hoped to make U.S. corporations more competitive internationally.

> Technology and industrial innovation are central to the economic, environmental, and social well-being of the citizens of the United States. Technology and industrial innovation are essential for an improved standard of living, increased public and private sector productivity, and enhanced competitiveness of the United States in world markets. Many new discoveries and advances in science occur in the universities and Federal laboratories, while the application of this new knowledge to commercial and useful public purposes depends largely upon actions by private industry and labor. Cooperation among academia, Federal laboratories, labor, and industry are required in the form of technology transfer, personnel exchange, joint research and development, and others to expand and strengthen the economy of the United States.[4]

A silver thread ran through the shroud of the Cold War: The world got cheaper and better products as a result of U.S. taxpayer support of research into technologies developed to keep the U.S. ahead of the Soviet Union. Now that the Cold War is over, American economic competitiveness is often the battle cry used to justify federal research, but it lacks the political urgency of the old national security mission. Research and development are the engines of economic growth. But who pays for it? And who benefits from it? These questions remain problematic for American politicians. "Competitiveness is not a politically powerful substitute for the Cold War in forging a durable, bipartisan coalition for supporting R&D."[5] Political support for federally funded research and development is beginning to unravel. Adjusted for inflation, the government's R&D expenditures have fallen 11 percent since 1988. Spending on R&D in the private sector has also fallen below the rate that increases output.[6]

Some WAYS

Legislative History

To derive maximum return on our country's technical investments, Congress has passed legislation to encourage the transfer of federally funded technology to the private sector. The Stevenson-Wydler Technology Innovation Act of 1980 (P.L. 96-480) began the process of technology transfer from Federal laboratories to universities, states, and industries. It also set aside 0.5 percent of the operating agencies' research budgets to fund the process. In 1986, Congress enacted the Federal Technology Transfer Act of 1986 (P.L. 99- 502)[7], which amended the Stevenson-Wydler Technology Innovation Act of 1980 to establish cooperative research and

development agreements (CRADAs) as a distinct method of transferring technology between government-operated laboratories and nonfederal organizations and to distinguish these agreements from standard federal procurement, grant, and research programs. Congress also mandated that technology transfer would be the responsibility of all laboratory employees; it would as well be subject to performance evaluations. In 1989, Congress expanded authority for these collaborations to federal laboratories operated by contractors when it enacted the "National Competitiveness Technology Transfer Act of 1989," National Defense Authorization Act for Fiscal Years 1990 and 1991 (P.L. 101-189 § 3131).[8] Under the legislation as amended, CRADAs are agreements between federal laboratories-- both government-owned, government-operated (GOGO) and government-owned, contractor-operated (GOCO)-- and their nonfederal counterparts through which both parties provide resources to conduct specified research and development efforts that are consistent with the missions of the Federal and National laboratories. The legislation grants federal agencies considerable flexibility in determining how to implement CRADAs. However, besides requiring that the collaborative work done under any CRADA be consistent with the laboratory's mission, the legislation establishes certain funding restrictions. While it allows private collaborators to provide cash, personnel, services, equipment, or other resources to conduct research and development (R&D), it limits the government's contributions to non- cash resources, such as equipment, personnel, and facilities. P.L. 101-189 § 3131 deleted the 0.5 percent funding that was established under P.L. 96-480. This change required Congress to appropriate other funding for CRADAs.

Means

Federally Conducted R&D

With more than 720 federal laboratories that employ more than one-sixth of U.S. scientists and consume nearly $25 billion a year for R&D, the U.S. government's investment in R&D is unequaled in the world. Federal R&D expenditures are currently reported as exceeding $72 billion annually.[9] However, this figure is misleading: Almost half is spent on such activities as establishing production lines, developing operational systems for new aircraft and weapons systems, and facility maintenance - which do not actually involve the creation of new knowledge or technology. Because these activities focus on existing technologies, they do not conform to the meaning of R&D. Though very important, they should not be included when evaluating the extent, vitality, and effectiveness of federal R&D. Excluding them reveals the true federal science and technology budget of $36.4 billion. Of the $36.4 billion of true R&D money, about $32 billion is used for civilian oriented R&D, so only about $4.4 billion is spent on real military-oriented R&D.[10] Civilian R&D has increased about 17 percent since 1993.[11] The CRADAs are funded from this $36.4 billion allocation.

CRADA Process

A CRADA is a legal agreement between one or more federal laboratories and one or more nonfederal parties. The purpose of a CRADA is to improve the transfer of commercially useful technologies from the federal laboratories into the private sector. Although their main purpose is to serve government needs, these laboratories have produced several thousand patents. Many of these patented inventions may have commercial applications. However, only approximately 5

percent of federal patents have been licensed. The United States cannot afford the luxury of isolating its government laboratories from university and industry laboratories. Endowed with the best research institutions in the world, this country is increasingly challenged in its military and economic competitiveness. Our national interest demands that federal laboratories collaborate with universities and industry to ensure continued advances in scientific knowledge and in its translation into useful technology. The ultimate purpose of federal support for R&D is to develop the science and technology base needed for a strong national defense, for the health and well-being of U.S. citizens, and for a healthy U.S. economy.

The CRADA process may be initiated by either a federal laboratory or a private entity proposing a research or development program. This can be done publicly through an advertisement or directly through private contact. Competitive biding is not required. After the parties agree, they establish a project which is appropriate for their facilities. They write a "joint work statement,"[12] which describes the purpose and scope of a CRADA, assigns rights and responsibilities among the agency, the laboratory, and any other party or parties to the agreement. The rights section establishes agreements on advance licence to patents on inventions, publication agreements, ownership of trade secrets and proprietary information, and financial information. This information is protected from disclosure or dissemination by a non-federal party for a period of up to five years after the conduct of the R&D (see P.L. 101-189 [103 STAT1676].)

Under the provisions that granted the GOGO laboratories the authority to enter into a CRADA, Congress also granted the laboratories the authority to grant advance licences to patents on inventions made by Federal employees, to waive the government's right of ownership in inventions made by an employee of a collaborating party, and to permit employees to help

commercialize their inventions to the extent the operating agency permits. These rights and authorities are permissive; they can be retained by the agency director.[13]

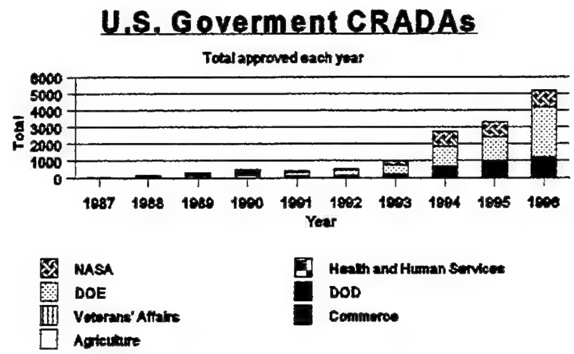
P.L. 101-189 §3131 did establish some specific differences in these provisions for GOCO federal laboratories (Department of Energy operated National Laboratories).[14] These laboratory directors are required to submit for approval both the CRADA and a joint work statement to the agency director. No work is to begin on the CRADA until final approval is obtained from the director of the operating agency. These documents must be submitted no more than 90-days apart. The agency director then has thirty days to approve or disapprove each of these documents and return them to the laboratory.

CRADAs, The Good, Bad, and Ugly

The GOOD:

The CRADA process is working reasonably well. But the process has not given private industry quick access to many as-built drawings of items to be manufactured, sitting on shelves in federal laboratories. Many members of Congress and executives in private industry believed that the federal laboratories would be a cornucopia of new products and technology that simply had to be opened. Rather, CRADAs are productive because basic and applied research activities are being carried out in true cooperation. CRADAs are only one of a number of mechanisms available to promote working relationships between private industry and federal laboratories. However, CRADAs differ from other means of technology transfer in that they are flexible enough to meet the needs of different industries, laboratories, research cultures, and R&D missions. As the following chart reveals, more than twelve thousand CRADAs have been

approved in the past ten years. Such a large number of CRADAs is not an absolute measure of their success, but it is a valuable indicator. Bruce Mattson, head of the office that works with intellectual property rights, CRADAs, licensing agreements, and disclosure statements for the National Institute of Standards and Technology (NIST), suggested that possible metrics for "perceived" success of CRADA could be the number renewed each year as well as the number of return customers. A company most likely would not renew a CRADA if its experience was bad, or if it did not benefit from the arrangements. As the CRADA program progresses and as government and industry gain more experience with CRADAs, more definitive data will become available for assessing CRADA effectiveness.[15]



CRADA effectiveness is extremely difficult to determine. Successful transfer of technology should result in new marketable products, increased productivity, more patents, overall industrial growth, or improvement in the environment. The American public is paying for this process. They should receive some measure of benefit in return. Several CRADAs have been cited for their ongoing or recent successes in contributing useful technology transfers to the commercial sector. The following are some examples of those successes:

- Engineers routinely use seismic waves to track down oil and gas reservoirs. In the Gulf of Mexico, however, salt domes scatter and distort the waves, so oil companies need help interpreting the data. Parallel computers that handle up to 100 problems at once cannot handle the problem. But massively parallel computers, capable of undertaking

thousands of computations simultaneously, can do the job. These computers would cost the oil companies close to $20 million.

Los Alamos National Laboratory (LANL) has the sort of computer that the oil companies need. So Marathon Oil, Shell Oil, nine other independent oil companies, and the Department of Energy (DOE) entered into a CRADA to solve the complex problem of identifying these reserves. This project should run for more than two years. The partners share the estimated cost of $8 million, as well as intellectual property rights. However, the estimated return to the U.S. economy should be more than $100 billion in consumer products and jobs. [16]

- Buena Vista Pictures Distribution needed a faster, safer, more precise method to ignite fireworks. Scientists at Sandia National Laboratory (SNL) had a semiconductor device from their research on explosives that they thought would perform the function. They modified it to meet Buena Vista's needs as part of a $733,000 CRADA. The intellectual rights to this semiconductor are estimated to return $1 million to DOE and generate $500,000 per year in sales for the next five years.[17]

- Somatix and Lawrence Berkeley National Laboratory (LBNL) established a $3.5 million, three-year CRADA in May 1994 to test a possible treatment of Parkinson's disease, a progressive neurological disorder.

Before getting involved in the CRADA, Somatix researchers had introduced Parkinson's in twenty-five rhesus monkeys. They then inserted into the primates' brains genetically engineered cells that overproduce an enzyme which promotes the production of dopamine, a neurotransmitter. Edward Lanphier of Somatix reports that, "People

develop Parkinson's because their cells' ability to make dopamine declines. The new cells should boost patients' production of the neurotransmitter."

Last year, after the monkeys got their new cells, LBNL scientists monitored the animals' dopamine production with both positive emission tomography (PET) and single-photon computer tomography scanning devices. The treatment looked so promising that the company hopes to start human trials during 1996.[18]

- Young lacewings will happily eat other insects, including such farmers' foes as aphids, whiteflies, leafhoppers, and mites. As part of a 2-year, $34,510 CRADA, Smuckers Manufacturing Co. and the Department of Agriculture's Agricultural Research Service (ARS) scientists developed a device that can spray onto plants both lacewing eggs and an adhesive that Smuckers had already developed. The glue holds eggs onto the leaves until the lacewings hatch and begin devouring pests. Smuckers began selling the device to farmers in November 1995.[19]
- The Precision Technology Airbag CRADA is an example of a breakthrough technology that benefited the partners, the public safety, the economy, the insurance industry, and many manufacturing companies. Sandia National Laboratory and Precision Fabrics Group collaborated for three years to develop an automobile airbag that is less than half the packed volume and weight of current airbags, yet it provides the same or more protection to passengers. Sandia's finite element code was a key factor in analyzing bag characteristics, as was lab experience with supersonic parachutes. Precision Fabrics Group provided the expertise in high-density fabric weaves and new materials. The value of this project has not been calculated.[20]

This set of examples is just a sample of the CRADAs considered successful. There are many more from DOD, DOE, Commerce, and other departments with federal laboratories. These laboratories, which have been seen as a gold mine of technology ripe for commercialization, also face a dilemma. There is no doubt that the federal laboratories have seen the light about CRADAs. They now see technology transfer as a way to leverage limited funds, which are important to their survival. CRADAs are now a way of doing business for them, not just fulfilling a regulation that requires them to perform technology transfer.

Indeed both partners appear to be getting their money's worth. A self-assessment of Sandia National Laboratory CRADAs showed 93 percent were "strongly associated with the laboratory mission and are a help to the industry partner."[21] Overall, 88 percent of the respondents to a survey of Sandia's industrial partners gave the laboratory a good rating of a four on a scale of five. They agreed that Sandia was responsive to queries. Sandia also met their expectations in achieving technical goals and projected milestones.[22]

The federal laboratories value the partnerships because they get the benefit of industry's expertise. Knowledge is passed in both directions, because the CRADA is a contact relationship. The laboratories benefit from drawing on industry's expertise to make small quantities of high-reliability and quality parts, for example. Under the emerging nuclear weapons stewardship focus, the National laboratories are assuming responsibility for manufacturing limited-life components in warheads as the traditional weapons plants are closed. Industry engineers are teaching their laboratory counterparts pertinent processes during the CRADA projects. The scientists often work side by side as equal contributors to the success or failure in the project.

Moreover, the CRADAs provide the nonmilitary work that the laboratories have been looking for since the end of the Cold War.

The Bad:

The government established several organizations to expand industry's access to federal R&D resources. These include the National Technology Transfer Center, Regional Technology Transfer Centers, Federal Laboratory Consortium Locator Network, Federal Laboratory Consortium, and the National Technology Initiative. The first three provide limited training to initiate a CRADA; they also help direct interested researchers to the right Federal laboratory.[23] The remaining two bring together scientists and engineers from academia, industry, and government to disseminate information on federal laboratory capabilities and resources.

Several federal organizations are noted for contributing technologies to the commercial sector, including the Defense Advanced Research Projects Agency (DARPA), the National Institute of Standards and Technology (NIST), the Department of Defense (DOD), and the Department of Energy (DOE).

DARPA: DARPA's mission is to exploit high-payoff, high-risk technologies with military applications. The agency tries to stimulate, develop, and demonstrate technologies that can trigger fundamental changes in future military systems and operations. It emphasizes dynamic technologies that are changing too rapidly to be captured by traditional research and development practices. DARPA funds are divided so that about 16 percent goes to universities, 11 percent to government laboratories, 60 percent to industry, and the remainder to administration. Program

managers are completely free to pursue technologies which they see as promising. The authority to enter into a CRADA rests entirely with the program manager.[24]

NIST: NIST's relationship with industry began in 1901 as the National Bureau of Standards. The Omnibus Trade and Competitiveness Act of 1988 assigned its mission in the transition of technology to the private sector.[25] NIST provides monetary grants directly to industrial groups and individuals under the "advanced technology programme" (APT). This money can be used to fund CRADAs that are administered by other agencies.

DOD: The DOD has granted all of the military branches and the directors of its research laboratories permission under the Federal Technology Transfer Act of 1986 (P.L. 99- 502)[26] and the "National Competitiveness Technology Transfer Act of 1989," National Defense Authorization Act for Fiscal Years 1990 and 1991 (P.L. 101-189 § 3131)[27] to enter into CRADAs. This means that the DOD laboratory directors have the flexibility to implement a CRADA as soon as one is proposed. The number of CRADAs that a DOD laboratory implements does not depend on the specific amount of funds designated for CRADAs within an R&D account, but rather on the laboratory manager's determination of the available resources--scientists and R&D facilities. Consequently, DOD laboratories cannot sort out the cost of efforts spent on CRADAs from that spent on other missions or R&D. Several Congressional committees have concluded that CRADA effort consumes between four and 25 percent of the DOD R&D budget.[28]

DOE: When DOE began implementing CRADAs in 1991, it adopted a centralized process of selection and funding that was very different from the decentralized "open-door" process used by NIST and DOD. For example, the approval process used in 1991 and 1992

included a headquarter-controlled, competitive selection process with money specifically identified and attached to each approved CRADA. [29] This structured DOE process was established for several reasons:

- P.L. 101-189 § 3131 requires the agency to review CRADAs and "Joint Work Statements" for GOCO laboratories. Most of the DOE laboratories are government-owned and contractor-operated laboratories.[30] Because of this law, DOE had to modify all of its contracts with the contractor-operators.
- DOE has a tradition of preventing outside direct access to the laboratories' secret weapons technologies because of past criticism of the DOE and their oversight of the laboratory contractors.[31]
- The DOE used the approval-disapproval process to prevent duplication of CRADAs. A DOE official pointed out to the Wells Commission that the number of DOE R&D facilities requires that the headquarters exercise tight, centralized control to prevent more than one laboratory from pursuing similar or the same cooperative research.[32] Furthermore, they wanted to select those CRADAs that they thought would have the greatest impact on increased knowledge and technology advancement.[33] DOE approvals of CRADAs were based on whether a proposal (1) focused on predetermined technology objectives chosen by headquarters program managers, (2) was directed to the stage of a technology's development that precedes commercialization (that DOE refers to as "spin-off"), or (3) was directed at specific energy-related industries that have been part of the DOE mission research in the past.

- DOE officials generally expected a collaborator to contribute an amount of cash or noncash resources to match closely dollar-for-dollar the value of the resources the DOE was expected to contribute. NIST and DOD had no such expectation or requirement.[34]

These and other factors led the DOE to initially centralize its process for implementing most of its CRADAs. DOE's initial practice of designating a specific amount of funds to support most of its CRADAs affected the number of CRADAs that it implemented. In effect, this practice set a "ceiling" on the funding available for CRADAs. For example, the large demand for CRADAs and the limits created by the funding ceiling allowed DOE's Office of Defense Programs to support only one out of nine proposals that it received from the laboratories. However, DOE laboratory officials said that resources -- scientists, engineers, and facilities -- were generally available because of the lack of other projects caused by the end of the Cold War and resulting change of nuclear requirements.[35]

The differences between the CRADA implementation process of the different agencies has generated an outcry from the industrial sector and several Congressional hearings. [36] Early Congressional investigations focused mainly on the number of CRADAs and the time required to implement them. Congress has applied pressure to increase the number of CRADAs and to shorten the time to get them approved. [37] During early Congressional inquiries, members of Congress interpreted their mission from the National Security Strategy of Engagement and Enlargement[38] to be "To highly encourage government/industrial partnership in technology and development to increase U.S./international competitiveness; to shift R&D in the federal enterprise from 60/40 military to 50/50 or less; to increase industry participation in the federal R&D labs

from 10 to 20 percent; to accelerate the time and ease of entering into CRADAs; to set R&D priorities and metrics of success on the federal R&D enterprise and to seek increased participation by industry in setting R&D priorities."[39]

The U.S. House of Representatives Committee on Science, Space, and Technology; Technology Transfer at Federal Laboratories, Hearing before the Subcommittee on Science, [40] investigated seventeen CRADAs from DOD, DOE, and DOC (Department Of Commerce). They also heard testimony from Lionel (Skip) Johns, Associate Director for Technology, Office of Science and Technology Policy, and Dr. H. Graham Jones, Director, New York Science and Technology Foundation. The chairman for this hearing was Congressman Rick Boucher of Virginia, Chairman of the Subcommittee on Science. This Subcommittee found nothing wrong with any of the objectives, the sponsoring laboratory missions, the funding involved, or the management of any individual CRADAs. They did determine that the CRADA approval process was broken. Furthermore, they investigated all the different processes and recommended the NIST system be adopted for the following reasons:

- Industry sets the priority of CRADA selection based on the marketability of the technology. It has a pull system driven by the market demand, rather than a push system where a demand must be created.
- The NIST allows CRADA approval at the project manager level.
- There are no funding or time limits. A CRADA can run for years and is complete when the industrial partner or the federal laboratory determines the CRADA is finished.
- All patent rights belong to the industrial partner and the government employees. The government is given a permanent licence to the patent or other intellectual property. This

part of the CRADA negotiations process is the most complicated and requires the most time.

The DOE had the most difficult process. However, simplifying the DOE process would require amending the existing laws. The DOE CRADAs are taking on the average seven and a half months to finalize after they have been approved. This sets the contracting time at about one year. Then comes the funding process, which has often taken more than a year because Congress must appropriate separate funding for DOE CRADAs. This is why industry complains that signing CRADAs with DOE laboratories is a protracted bureaucratic quagmire. The Secretary of Energy is well aware of the problems; she has committed the Department to streamlining the CRADA process and reaching small businesses more effectively.

Both the U.S. Senate and the U.S. House of Representatives responded to the results of their hearings and to pressure from industry by drafting bills to amend the existing laws and to streamline the CRADA process: S. 1537, The Technology Commercialization Act of 1993 [41]is the Senate version and H.R. 1432 -- The DOE Laboratory Technology Act of 1993[42] is the House legislation to refine the CRADA process. These bills are intended to speed up the CRADA process by allowing the DOE to permit the GOCO laboratories to approve CRADAs, to combine the CRADA agreement and the "Joint Work Statement" into one document, and to clarify the intellectual property rights and agreements. But before a compromise bill could be passed, the results of the Galvin Commission[43] were reported.

"CRADAs currently occupy pride of place among the array of mechanisms employed by the DOE to encourage laboratory-industry cooperation," states the report of an independent task force headed by Robert Galvin, former chief executive officer of Motorola and a member of the

company's Board of Directors. The panel, which released its report in February 1995, reviewed 10 of the department's research facilities and recommended ways in which DOE might change them to meet the needs of the nation.

The Galvin commission, along with other experts, cast a critical eye on DOE's recent enthusiasm for CRADAs. They argue that the agency has failed to follow rules dictating the federal laboratories work only on projects that tie closely with their missions. They cited DOE's CRADAs with the textile industry as examples that fail to support the agency's mission. One such CRADA between Brookhaven National Laboratory in Upton, N.Y., and Cotton, a firm in Raleigh, N.C., involves genetic analysis of cotton plants to help breeders produce better ones.[44] DOE has "engaged in a pretty indiscriminate effort to find industrial collaborators who might be interested in its technology . . . There's been, recently, very little effort to focus these efforts," contends Richard K. Lester, a Galvin task force member and director of the Massachusetts Institute of Technology's Industrial Performance Center. "We were not able to tell from data provided to the panel what fraction of these CRADAs were very successful, partly successful, and not successful at all," Lester observed.[45]

A series of Philadelphia Inquirer articles criticizes the government agency's CRADAs with companies. The newspaper concludes that the government's CRADAs in general "suffer from duplication, inflated management costs, and exaggerated claims of success." Most importantly, the programs have failed to produce the jobs that their supporters promised.[46] However, Nuno A. Vaz (General Motors Corporation's Director of Government Partnerships in Warren, Michigan) said, "Before CRADAs existed, representatives of industry used to sit on opposite sides of the table with government. Now we sit on the same side . . . The change of

atmosphere is enormous. A couple of years ago Congress was claiming the National Laboratories where not giving out enough CRADAs. Now that these laboratories are doing what they were told they should be doing, Congress accuses them of wasting money. Where is the guidance? We sure hope that the GOP understands the great advantage there is to CRADAs." No matter what the critics say, GM has nothing but praise for its CRADAs. The automaker's 50-plus agreements, primarily with DOE, are helping it to develop better batteries, turbines, exhaust systems, and more. [47] But the Galvin report disagreed, warning that the DOE was competing with private firms that could offer the technical services CRADAs now provide.

The UGLY:

The new Republican leadership poses the biggest threat to the laboratories' relationships with industry. Some members of Congress do not like the CRADAs, calling them "corporate welfare." They do not want the government in the business of creating winners and losers among industries by providing certain companies assistance using government assets.[48] Hundreds of CRADAs face dissolution because of budget cuts being supported by the Republican majority in Congress. Figure 2, below, shows the proposed budget changes for the administration and Congress. Dana Rohrabacher (Republican, California), chairman of the House Subcommittee on Energy and Environment, claimed "The CRADA work should end to leave room in the budget for basic research. These are nice things to do, but they should not be done at the expense of real scientific work."[49]

The question of whether the Federal government should help private industry to develop technology has now become a point of disagreement between the Administration and the Congress.

Figure 2.

PRESIDENT AND CONGRESSIONAL FUNDING DIVISIONS OVER SCIENCE CRADAs					
Program	Agency	1995 Funding	President's 1996 Request	House Funding Level 1996	Senate Funding Level 1996
National Iqnition Facility	DOE	$5 million	$61 million	$33.6 million	$61 million
Stockpile Stewardship	DOE	$1.46 billion	$1.59 billion	$1.35 billion	$1.7 billion
Solar and Renewable Energy Research	DOE	$418 million	$423 million	$266 million	$321 million
Mission To Planet Earth	NASA	$1.34 billion	$1.34 billion	$1 billion	$1.28 billion
Advanced Technology Program	NIST	$341 million	$491 million	- 0-	$25 million
Landsat Remote Sensing	NIST	- 0-	$12 million	- 0-	$10 million

Source 1996 Appropriations Bills, U.S. Congress

The conflict is being watched closely by all the government laboratories. They are looking for different options to save their programs. Warren Siemens, technology transfer manager at Sandia National Laboratories, hopes that most of the laboratory's CRADAs, which generally last for three years, will be maintained with money from the weapons stewardship program. He says that if there is no available money from the weapons program or if the laws prevent the CRADAs from rolling over into the main programs, then "we would have to terminate all the CRADAs and seek to renegotiate them. But at that point, industry would pick up its bag and go home."[50]

Kathleen N. Kingscott, program director for science and technology for International Business Machines Corp., said, "One of the big concerns with the terminations of CRADAs is that many companies have made significant investments and commitments on the basis of their awards. People were hired and materials purchased. Early termination of these agreements will undermine trust in the government as a partner. What we are asking the government to do is honor its

commitment."[51] Furthermore, the termination of CRADAs would be devastating to U.S. technological advances, promising severe economic consequences. Many of the large company owned research and development laboratories have been dismantled. A company usually cannot capture as much of the economic value from an advance in fundamental knowledge as it can from an advance in a product or production technique.[52] Many companies now rely on the CRADAs and a few of their employees working on site at the government facilities to generate the technological breakthroughs which will keep the companies competitive. They concentrate the majority of their scientists and facility efforts on commercializing the breakthrough discoveries.

For example, scientists at AT&T Bell Laboratories once practiced a researcher's dream, following their own curiosity while another department decided whether and how to commercialize their discoveries. With the breakup of Bell Laboratories, this dream is over. Most of the scientists work for the split-off companies that make equipment. Others work for the company that provides the services. Their goal is to produce incremental improvements in existing products.[53] Basic research and development at Bell Laboratories is a thing of the past.

This is a major change in the mission of Bell Laboratory when it was viewed as the crown jewel of American industrial research. For many years Bell Laboratories sponsored a large program of long-term basic research, out of which flowed many fundamental discoveries, from the transistor to the universe's microwave background. This turning away from long-range research, however, is not the folly of short-sighted business managers, but a rational adaptation to changes in the government/industrial research relationship. The computer, electronics, and telecommunications business is fast-moving, highly competitive, and increasingly dominated by

companies that are narrowly focused. This prompted companies to specialize and carry on research through government consortiums by means of CRADAs.

In the old days, a company would have the leisure of years to develop a product. For example, although xerography was discovered in 1938, it was not until 1950 that Xerox Corporation commercialized it. And Xerox had the time to develop and patent a range of related technologies.

In contrast, when IBM scientists discovered high-temperature superconductivity in 1987, it was only a few weeks until other research groups repeated and advanced the discovery. If this discovery generates a new field of commercial possibilities in the future, it will be impossible for IBM to lock it up and maintain control. The result is that IBM spent millions of dollars on a discovery that is diluted in value. [54] Both large and small companies now have come to rely on government research laboratories and CRADAs to advance their needs.

The Bottom Line

CRADAs are not intended to be basic research programs that simply accumulate new knowledge. Their objective is to provide U.S. industry with the technical edge to remain internationally competitive. CRADAs assist the private sector in creating new economically viable products, product improvements, processes, and/or procedures using leading edge research and development. CRADAs are the most efficient means of enabling technological collaboration between government laboratories and private firms. However, despite some initial successes, politics and funding uncertainties cloud the future of CRADAs. Federal policy-makers need to adopt a new way of budgeting the funding for science and technology if the United States

is to remain a world leader in research and development. Our continued lack of a National Strategic Technology Policy with specific ends, ways, and means threatens America's technological superiority. If we accept that "technology is now the universal engine of economic growth,"[55] then we must work to maintain and improve that engine. The United States must take immediate steps to maintain its technology lead and increase its future economic competiveness.

First, the federal government must develop a National Strategic Technology Policy and implement a technology development and resource plan. The plan should address:

- R&D metrics
- Long-term funding strategy
- Critical areas of effort
- Parameters for technology transfer to foreign nations
- A clear, consistent CRADA process model that reduces actual and perceived red tape that discourages signing of these agreements.

Second, the government should establish a joint industry, university, and government forum to set government R&D priorities and delineate roles and responsibilities related to technologies. This forum should include representation from small business to insure that the diffusion of knowledge is equally shared. Furthermore, the exact role of the federal laboratories needs to be defined to allow them to maintain their ability to produce both swords and plowshares. The U.S. government should restructure the federal laboratory system to eliminate excessive duplication of effort and to increase efficiency.

Third, the federal government should offer industry tax incentives for basic research. The private sector needs to maintain a healthy measure of independence from the government laboratories. CRADAs encourage industry to become dependent on the federal government.

Summary

Under the present CRADA selection processes, CRADAs might reach the goals set out in the National Security Strategy of A National Security Strategy of Engagement and Enlargement. They do advocate U.S. business interests by providing assistance to meet the needs identified by industry. However, the piecemeal system is inefficient and random. There is no way to evaluate their overall strategic effectiveness because the United States does not have an identified set of strategic technologies or R&D vision guidance statements which establish national priorities.

The National Academies of Sciences and Engineering, the Institute of Medicine, and the Galvin Commission all say that " federal policy-makers need to adopt a new strategic way of budgeting the funding for science and technology if the United States is to remain the world leader in research and development during this time of fiscal constraints."[56] The new approach should include combining the many disjointed pieces of federal science and technology funding into a single budget picture. The President and Congress should use the budget process to ensure that the Unites States is preeminent in selected fields of science and technology that are especially promising or are important for achieving national goals.

As tools of technological improvement, CRADAs have much to recommend them. They are to some extent market-driven, being instigated and paid for in part by industry. They also set targets, so their success or lack of it can be measured. They are temporary. And their results

become common property, though the companies in the CRADA do get exclusive rights for a specified period.[57] The CRADA process should continue because it does add value to America. Immediate benefits from CRADAs are limited, but long-term gains will result from this cooperative research. The federal government's proper role in these ventures is to provide the vision through a National Strategic Technology Policy. CRADAs are only tools to help implement that policy. Exploiting federally developed technology is only the beginning.

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